ALTERNATIVE BUDGETING — DOES PERT/COST FURNISH MEANS FOR TOTAL MANIFESTATION?

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ALTERNATIVE BUDGETING--DOES PERT/COST FURNISH MEANS FOR TOTAL MANIFESTATION?

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INTRODUCTION

Purpose

In the Winter 1952 issue of the Public Administration Review, Verne B. Lewis had an article titled "Toward a Theory of Budgeting."[1] His basic purpose was to suggest a budget system based upon economic theory. He called his proposed system the Alternative Budget System. It furnished a basis for budgetary decisions and provided a degree of budget formulation flexibility. The primary purpose of this thesis is to suggest an area for the application of the alternative budget system within the Department of Defense.

The Problem

There are two basic questions which must be answered to fulfill the purpose of this thesis. First to what degree, if any, have the concepts and mechanics of the alternative budget system in effect been adopted in the Department of Defense?

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[1]Verne B. Lewis, "Toward A Theory of Budgeting," Public Administration Review, Winter 1952, pp. 42-54.

Second, if the system has been partially adopted, is there an area or technique which would allow a more complete adoption of the system? The first question may be subdivided into the subordinate questions of what are the concepts and features of alternative budgeting and to what extent have they been implemented in the Department of Defense? These questions are answered in Chapters I and II respectively. The second basic question may be subdivided into the questions of what is an area or technique which is compatible with alternative budgeting and how can they be integrated? Chapter IV attempts to answer these questions. This paper considers only the area of budgeting for research and development programs controlled by a PERT/COST system.

The Approach

Library research was the primary method of investigation utilized to obtain the necessary information to answer the primary and secondary questions. The basic classes of literature utilized were management texts and periodicals, government management and proceedural publications, economics texts, military periodicals, and public administration periodicals. Other sources of information were formal and informal speeches, management seminars, and interviews.

Chapter I attempts to thoroughly examine the concepts and features of alternative budgeting. It defines general budgeting

and discusses its benefits. The need for and approaches to budget flexibility are examined with a view toward the federal budget. The complexity of governmental budgeting from the magnitude, political and economic standpoints is explored.

Lewis suggested that the economic theories of relative value, incremental analysis, and relative effectiveness could combine to form the basis for an economic theory of budgeting.[1] The theories are examined in the light of the underlying principle and concepts applicable to each. Lewis's evaluation of the budget system as it existed in 1952 is presented, and his proposed alternative budget system is discussed and evaluated.

The second chapter seeks to determine the answer to the second subordinate question. To what degree have the concepts and mechanics of the alternative budget system been adopted in the Department of Defense? The chapter does not present a detailed description and analysis of budgeting within the Department of Defense. However, it does make a comparison of the present concepts and practices to those of the alternative budgeting theory as discussed in Chapter I. The DOD budget process is discussed and examined in each of its three phases: planning, programming and budgeting.

Planning is considered only in relation to the two remaining phases. Some stress is placed on the economic concept

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[1] Ibid., p. 42.

of marginal return of satisfaction with regards to force structure balance. Programming is examined in some detail to determine its relation to the economic concepts of budgeting and the physical system suggested by Lewis. The actual budgeting proceedures and features are compared to those of the alternative budget system. In this section emphasis is placed on the factors causing budgetary change and ability of the budget to react.

Chapter III reviews the Program Evaluation and Review Technique (PERT), a new management planning and control tool now used in many Department of Defense research and development projects. It is reviewed because an extension of the system (discussed in Chapter IV) appears to have features compatible with the alternative budgeting system, and it is the purpose of this thesis to suggest an area for complete application of alternative budgeting in the Department of Defense. To understand the subject extension, the reader must have a basic understanding of the concepts and features of PERT. The review traces the history and applications of PERT/TIME and PERT/COST and discusses their features and limitations. The discourse only attempts to enable the unfamiliar reader to gain a basic understanding of the technique.

The Time-Cost Option Supplement, an extension of the PERT system, is discussed in Chapter IV. The object of the discussion is to determine if the features of the supplement

are compatible with those of the alternative budget system. To make the determination, the technical features of the supplement and the interrelationships of the inputs of time, cost, and risk are examined in some detail. Assuming that a degree of compatibility is established, a proposal is made to increase the degree of integration between the concepts underlying the Time-Cost Option Supplement and alternative budgeting.

The final chapter contains the conclusions drawn from the analysis of the previous chapters. The conclusions are specifically related to the four subordinate questions raised in this introduction. For the benefit of the cursory reader, the conclusions are integrated with a brief summary of the data so they constitute a synthesis of the thesis.

CHAPTER I

THE THEORY OF ALTERNATIVE BUDGETING

Features Of Alternative Budgeting

Comparison of Alternatives

The public budget was looked on by Lewis as a problem of relative values to be examined by the methods of incremental analysis and relative effectiveness.[1] His clue for the method of presentation of the results of his economic analysis came from the writings of Key who stated:

> Perhaps the approach toward the practical working out of the issue lies in canalizing of decisions through the governmental machinery so as to place alternatives in juxtaposition and compel consideration of relative values. This is the effect of many existing institutional arrangements but the issue is rarely so stated, and the structure of government, particularly the federal-state division, frequently prevents the weighing of alternatives.[2]

Lewis agreed that alternatives should be placed in juxtaposition, but he disagreed with Key's contention that existing institutional arrangements and structures prevented the weighing of alternatives within the federal government. He felt that the

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[1] Ibid., p. 46.

[2] V. O. Key, "The Lack of a Budgetary Theory," American Political Science Review, Dec. 1940, p. 1142.

federal budget forced a nearly simultaneous consideration of all the competing claims by the President and the Congress. In addition, he believed the budget forced consideration of the relative merits of competing claims within each jurisdiction at each administrative level. The problem was that while the existing system forced comparison of alternatives it furnished little light on the effects of possible budgetary adjustments on individual programs or projects.[1]

Mechanics

To facilitate the comparison of relative merits, Lewis outlined a system which allowed examination of the interprogram and intraprogram facets of the budgetary problem. He named the system "The Alternative Budget System."[2] Its basic approach is the application of the methods of incremental analysis and relative effectiveness to the relative value problem. Lewis explained the mechanics of the system as follows:

> Under this proceedure, each administrative official who prepares a budget estimate, . . . , would be required to prepare a basic budget estimate supplemented by skeleton plans for alternative amounts . . . . The number of alternatives might vary with the situation . . . . Increments of 10% might be appropriate in some cases; larger or smaller increments might be required in others.[3]

He recommended selection of the amount likely to be approved as the starting point. Then the other estimates would reflect the

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[1]Lewis, loc. cit., pp. 48-49.

[2]Ibid., p. 49.

[3]Ibid.

effect of changes generated due to budget slashes or increases.

Lewis viewed the establishment of the alternative levels as a process which began with the President and proceeded down the hierarchical levels of government to the working level. He stated:

> The establishment of the alternative levels would have to start with the President. He would select several alternatives of overall government expenditure, and he would establish corresponding alternative levels for each department or agency. The head of each department or agency would, in turn, establish alternative levels for each of his subordinates which would be consistent with the prescribed departmental levels.[1]

The President, by selection of the primary alternatives, would determine the overall latitude and flexibility of the system.

Flexibility

Seven fundamental principles of budgeting as related to managerial planning by Glenn A. Welsch are: organization, responsibility accounting, participation, timeliness, confidence, flexibility and realism. The essentials related to effective budgetary control are the principles of: individual recognition, organization, effective communication, standards, management by exception, follow-up, flexibility, and cost consciousness.[2] The only principles included on both lists are organization and flexibility. Let it suffice to say that

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[1] Ibid.

[2] Glenn A. Welsch, "Budgeting for Management Planning and Control," The Journal of Accountancy, Oct. 1961, pp. 38-40.

organization furnishes the physical framework in which the budget must function. Budget flexibility is a fundamental prerequisite to successful budgeting.

Budget flexibility implies that managerial planning and control are responsive or readily adjustable to changing conditions. The quest for flexibility is an underlying concept of this thesis. If a budget is to have real meaning, it must be capable of adjusting to changing conditions. Lacking this attribute, management may find its budget is attempting to flow against the tide, or management is not able to react in time to abort losses or ensure gains. A rigid budget also tends to allow complacency to develop. Pierce states that:

> Excessively rigid adherence to a budget may cause unprovided for opportunities to be overlooked. If the budget is being kept within limits people may become less alert in their efforts to reduce costs.[1]

A budget should contain provisions to adjust to changing conditions. Only then will it reflect or be the basis for rational decisions in a changing environment.

The predetermined levels of activity inherent in the alternative budget system allow a certain degree of flexibility in governmental budgeting. Much of the budget is fixed. As a former assistant director of the Bureau of the Budget stated:

> . . . budget proposals for any given year are prepared as it were, in something of a financial straight jacket. Decisions of past years, programs begun long ago, past

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[1]James L. Pierce, "Control By Budget," The Controller, July 1957, p. 329.

> wars, existing national debt--all these and other factors, cause "fixed" expenditures in amounts and proportions which are astonishingly large.[1]

However, for those programs that can be adjusted, the desirability of flexibility has been recognized. A former Director of the Bureau of the Budget, David E. Bell, stated:

> It seems to me that it is of the greatest importance for us to attempt to put down sets of figures which indicate where the budget will be some years from now under specified assumptions. It is, of course, true that the assumptions will change. It may be highly desirable to prepare alternative sets of figures related to alternative assumptions about future events.[2]

The amount of uncertainty for the enterprise within its environment should govern the scope and number of the alternate plans. It may be impossible to have a plan for every contingency. However, adequate coverage may be possible. Professor John T. Wheeler stated that there are many situations where a few alternative plans can cover almost all possibilities. He goes on to state:

> How much better it is to have alternative plans formulated to use under a different set of circumstances from those assumed for the primary plan. Then when the circumstances under which action must be taken are known, the appropriate plan can be chosen and put into effect to achieve both

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[1]John A. Beckett, "The Processes and Control Issues of the Federal Budget," The Controller, June 1959, p. 282.

[2]An Address by David E. Bell, Director, Bureau of the Budget, at the 17th Annual Meeting of the National Association of State Budget Officers, Gatlinburg, Tennessee, Aug. 21, 1961 (Copy available in the library of the Bureau of the Budget), p. 7.

efficient action and coordination.[1]

This approach emphasizes the changing of the forecast environment and attempts to have a plan to cover all reasonable contingencies.

For those programs that can be adjusted, the alternative budget system allows as much flexibility as is desired. The only limit would be the expense of preparing the alternate budget levels. Although the preparation of supplements to a basic budget proposal is expensive, the benefits gained can far outweigh the increased cost. This will be true as long as only alternatives that have a chance of selection are prepared and an excessive number of alternatives are not prepared. Budget preparation itself is subject to the law of diminishing returns.

Basis for Decisions

Budgetary decisions are concerned with and affect future events. In order to arrive at an effective rational decision it is necessary to predict the events and environment of the future. In other words, a judgement of the future must be made before a budget can be prepared. The executive must have adequate information upon which to base a decision. The lack of adequate information may lead to a bad decision. As Albers states:

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[1]John T. Wheeler, "Is There Any Such Animal," Business Budgeting, Jan. 1958, p. 18.

> The executive's knowledge of the factors that may influence the outcome of a decision is always limited. A major difficulty is that decision-making is concerned with future behavior that cannot be predicted with a high degree of certainty.[1]

The alternative budget system furnishes more information for the budget formulater, reviewer, and approver. When resources are limited, and they usually are, the relative value of individual programs and the effects of incremental adjustments can be predicted with a degree of certainty. The system furnishes another tool for analysis.

Lewis feels that there are two other general advantages of the system with regard to decision-making. First, budgets with supplemental alternatives would have a greater palatability to the operating officials who must approve and justify budgets. In addition, the system allows the modification of an official's basic decision without weakening his stature and usefulness.[2]

Compatibility

To a great degree, the alternative budget system can incorporate the salient points of the governmental budget methods and techniques now in use. The system emphasizes the advantages of fixed-ceiling budgeting and work load measurement and unit costing. It overcomes the limitations of the forementioned techniques and the open-end budgeting and increase-decrease analysis techniques. Features such as priority

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[1]Henry H. Albers, Organized Executive Action, New York: John Wiley and Sons, Inc., 1961, p. 203.

[2]Lewis, loc. cit., p. 53.

listings and item by item control can be incorporated within or as an addition to the system. The supplemental nature of the system makes compatibility a minor problem.

Applicability Of Economic Concepts For Governmental Budgeting

The expenditure side of public budgeting was viewed by Lewis as being essentially applied economics.[1] The basic question is: On what basis shall it be decided to allocate X dollars to A instead of B when there are not enough for both? Burkhead defined the governmental budget as the plans for government finances submitted for the approval of the legislature.[2] It has been said that the core of the governmental budget process is the analysis and balance of governmental projects.[3] If one accepts the definition of economics as a social science that has to do with man's activities in satisfying his wants through the use of limited resources having alternative uses, it follows that the governmental budget process is concerned with the problem of satisfying the wants and needs of the people through the use of resources too limited to satisfy all the requirements. In other words, an

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[1] Ibid., p. 42.

[2] Jesse A. Burkhead, Government Budgeting, New York: John Wiley and Sons, Inc., 1956, p. 2.

[3] Fritz M. Marx, "The Bureau of the Budget: Its Evolution and Present Role," The American Political Science Review, August 1945, p. 661.

economic choice must be made between projects. All desirable projects cannot be undertaken with the resources available.

Other writers consider the basis for governmental budgetary decisions to be more political than economic. The budget has been described as being the core of legislative control and executive management of our government. It largely determines the success or failure of our governmental process.[1] The governmental budget as it now exists may be considered as a reflection of our political system. Any proposed reforms of the system can be said to possess political implications. Wildavsky stated the problem very pragmatically when he wrote:

> A large part of the literature on budgeting in the United States is concerned with reform. The goals of the proposed reforms are couched in similar language--economy, efficiency, improvement, or just better budgeting . . . . There is little or no realization among the reformers, however, that any effective change in budgetary relationships must necessarily alter the outcome of the budgetary process. Otherwise, why bother? Far from being a neutral matter of "better budgeting," proposed reforms inevitably contain important implications for the political system, that is for the "who gets what" of governmental decisions.
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> The budget is the life-blood of the government, the financial reflection of what the government does or intends to do. A theory which contains criteria for stating what ought to be in the budget is nothing less than a theory stating what the government ought to do. If we substitute the words "what the government ought to do" for the words ought to be in the budget, it becomes clear that a normative theory of budgeting would be a comprehensive and specific political theory detailing what the government's

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[1]Harold D. Smith, "The Budget as an Instrument of Legislative Control and Executive Management," Public Administration Review, Summer 1944, p. 181.

activities ought to be at a particular time.[1]

The governmental budget in essence results from and contributes to the political process. Practical budgeting can be considered as applied politics.

At the same time the budget serves an economic purpose. The budget does decide the political question of "who gets what," but it also has a specific and an aggregate economic effect. Gerhard Colm stated:

> The budget at the same time serves both a political and an economic purpose, and these purposes are often in apparent conflict with each other.
> . . . . . .
> The problem of budget reform is to find a way to reconcile two sometimes diverse ends.[2]

He advocated a new economic rule to guide government budget policy.[3] It is apparent that governmental budget decisions must consider and are affected by the economic and political factors involved.

Although the basis for governmental budgeting decisions may be economic or political, or both, economic concepts are applicable. As Key stated:

> Whether budgetary behavior is economic or political is open to fruitless debate; nevertheless, the point of view and the mode of thought of the economic theorist are relevant

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[1]Aaron Wildavsky, "Political Implications of Budgetary Reform," Public Administration Review, Autumn 1961, p. 183-184.

[2]Gerhard Colm, "The Federal Budget and the National Economy," National Planning Association Bulletin No. 90, March 1955, pp. 36-40.

[3]Ibid., pp. 41-53.

> both in the study of and action concerning public expenditure. The budget-maker never has enough revenue to meet the requests of all spending agencies, and he must decide (subject, of course, to subsequent legislative action) how scarce means shall be allocated to alternative uses. The completed budgetary document (although the budget-maker may be quite unaware of it) represents a judgement upon how scarce means should be allocated to bring the maximum return in social utility.[1]

Specific theories of economics can be useful in determining the basis for allocation of scarce resources among competing demands.

An Economic Theory Of Budgeting

Lewis said that the basic question of allocation of scarce resources could be analyzed in view of the following economic theories:

1. The theory of relative value.
2. The theory of incremental analysis.
3. The theory of relative effectiveness.[2]

He believed that they would combine to form the basis for an economic theory of budgeting.

Relative Value

The theory of relative value states that the return from every expenditure must be worth its cost in terms of sacrificed alternatives.[3] Inherent in the theory are the principle of balance and the concept of opportunity cost. Professor Pigou

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[1]Key, loc. cit., p. 1138.

[2]Lewis, loc. cit., p. 42.

[3]Ibid., p. 43.

explained the principle of balance as follows:

> As regards the distribution, as distinct from the aggregate cost, of optional government expenditure, it is clear that, just as an individual will get more satisfaction out of his income by maintaining a certain balance between different sorts of expenditure, so also will a community through its government. The principle of balance in both cases is provided by the postulate that resources should be so distributed among different uses that the marginal return of satisfaction is the same for all of them . . . . Expenditure should be distributed between battleships and poor relief in such wise that the last shilling devoted to each of them yields the same real return. We have here, so far as theory goes, a test by means of which the distribution of expenditure along different lines can be settled.[1]

Stated simply, an equal marginal return of satisfaction for all expenditures is the essence of the principle of balance.

The concept of opportunity cost emphasizes the judging of costs in relation to their results and not in relation to their magnitude alone. The English economist, L. M. Fraser, defined opportunity cost as the amount of other things which have to be given up for its sake.[2] Hence the cost of anything can be viewed in terms of what also could have been purchased with the funds.

Incremental Analysis

The theory of incremental analysis is applied to the additional values to be derived from each expenditure.[3] If

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[1]Pigou, quoted by Key, loc. cit., p. 1139.

[2]L. M. Fraser, Economic Thought and Language, London: A. and C. Black Ltd., 1937, p. 103.

[3]Lewis, loc. cit., p. 44.

available resources are divided into increments, it is much easier to determine where the phenomenon of diminishing utility is encountered. Marshall states that point exists when:

> The total utility of a thing to anyone increases with every increase in his stock of it, but not as fast as his stock increases. If his stock increases at a uniform rate the benefit from it increases at a diminishing rate. In other words, the additional benefit which a person derives from a given increase in his stock of a thing, diminishes with every increase in the stock that he already has.[1]

The marginal utility theory concentrates upon the increments where diminishing utility takes effect. This is an extremely important area for information relating to project balance.

Relative Effectiveness

The theory of relative effectiveness is concerned with the comparison of the relative merits of the different means of achieving a common objective.[2] One problem is the comparison of unlike means, with unlike effects, in achieving a common objective. The answer depends on the relative needs of the means and forecasts of facts concerning the objective and means.

The problem of the precise quantification necessary for the applications of the three economic theories was recognized by Lewis. However, he maintained that the concept was still valid when he wrote:

> Whether firm numbers are available or not, judgments and decisions have to be made. The lack of precise numbers

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[1]Alfred Marshall, Principles of Economics, London: Macmillan and Co. Ltd., 1961, p. 92.

[2]Lewis, loc. cit., p. 45.

> does not invalidate the basic principles or methods of calculation which we have outlined. The methods have to be judged on the basis of whether or not they lend to proper conclusions if it is assumed that the numbers used in the equations are the right ones. Obtaining the right numbers; though a fundamental and difficult problem, is separate and distinct from the problem of developing methods of calculation.[1]

Later discussion will show that the problem still exists.

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[1] Ibid., p. 46.

CHAPTER II

COMPARISON OF DEFENSE BUDGET PROCESS AND ALTERNATIVE BUDGETING

Budget Cycle

It is no longer possible to discuss the budget process within the Department of Defense as a separate entity. The advent of the program package concept forces the integration of planning, programming, and budgeting within the department. Captain Harry C. White and Lieutenant Commander Massey in their article, "Program Packaging--Opportunity and Peril," described the budget cycle as being divided into three phases.[1] The first is a review of requirements where the general needs for military capability are determined. The second phase compares the cost and effectiveness of each program. The third phase consists of the traditional budget formulation and review. These three phases are respectively called the planning, programming, and budgeting phases.

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[1]Harry C. White and R. J. Massey, "Program Packaging--Opportunity and Peril," United States Naval Institute Proceedings, Dec. 1961, p. 23.

Planning

Planning is defined by Mosher as the conceiving of goals and the development of alternative courses of future action to achieve the goals.[1] Translated into a military context this would read as the conception of our goals and the development of various means to satisfy them. Plans determine objectives and in turn are determined by them. As Albers states:

> The first step in the planning process is the determination of objectives and the next step is to plan activities or decide how objectives are to be achieved. Although such a sequential approach to planning is useful for analytical purposes, the idea that objectives and plans are mutually dependent concepts should not be neglected. Objectives determine the nature of activities that will be necessary, but at the same time, the operations that are planned operationally determine the objective.[2]

The selection of objectives is in itself a determination of the degree to which needs may be satisfied. The military planner is primarily concerned with requirements and goals, but he must be conscious of the costs of implementing his alternative plans.

Preparation of the most efficient plan possible within his budgetary or other limitations should be the goal of the planner. In addition, a balance must be struck to achieve the greatest overall effectiveness. An inopportune choice could

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[1]Frederick C. Mosher, Program Budgeting: Theory and Practice, New York: American Book-Stratford Press, Inc., 1954, p. 48.

[2]Albers, loc. cit., p. 298.

result in an establishment incredibly strong in one area and woefully weak in another. One only needs to be reminded of the chain with its weak link to realize the dangers. Unfortunately, the need for balance makes an economic analysis more difficult. Hitch and McKean emphasized the problem when they stated:

> Since military capabilities are plural and not easily commensurate, an efficient military establishment, in the technical sense, would merely be one in which no single capability--anti-submarine, ground warfare, offensive air, and so on--could be increased without decreasing another. An optimal establishment would in addition have the right "balance" among capabilities--a harder problem for analysis.[1]

Only if balance is maintained will the marginal return of satisfaction be the same for all expenditures.

Programming

Development

The selection and comparison phase of the budget cycle is accomplished within the programming system. This system is concerned with comparing alternate methods by their costs, their effectiveness, and their feasibility in accomplishing specific missions.[2] The system was developed to bridge the gap that existed between planning and budgeting. Prior to the

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[1]Charles J. Hitch and Roland N. McKean, The Economics of Defense in the Nuclear Age, Cambridge: Harvard University Press, 1961, pp. 123-124.

[2]U. S., Department of Defense, Study Report on the Programming System for the Office of the Secretary of Defense, June 25, 1962, p. II-1.

inception of the system, no system had been formalized for the reviewing, approving or controlling the relation of budget programs to missions for either the budget year or the years immediately afterward. In the spring of 1961 Secretary of Defense McNamara, as quoted in Program Change Control System in the Department of the Navy, announced that the major objectives of the programming system would be:

1. To plan programs around major missions rather than Services.
2. To relate resources--manpower, material, equipment and the like--to military output.
3. To coordinate long-range planning with budgeting.
4. To appraise programs on a continuous basis.
5. To control approved programs through timely progress reports.
6. To provide a capability for making cost-effectiveness studies of alternate force structures.
7. To integrate OSD information systems in order to avoid duplication.[1]

The budgets for the fiscal years 1963 and 1964 have resulted from the programming system.

Selection of Programs

The need for a definative approach in making military decisions is implicit in the following statement:

> Modern-day weapons are complex and costly, require lengthy periods for research and development, and have tremendous combat capability. These facts make it essential that unusual care and consideration be placed on the sound choice of major weapons systems in relation to tasks and missions.[2]

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[1]U. S., Department of the Navy, Office of the Comptroller, Program Change Control System in the Department of the Navy, NAVEXOS P-2416, August 1962, p. iii.

[2]Ibid., p. I-3.

Such an approach must result in answers which yield degrees of preferredness. Otherwise it is meaningless.

The programming system is designed to supply information for cost-effectiveness studies which can be used as a basis for choosing among alternative means to a given end. A Department of Defense study viewed the system as a method of achieving maximum effectiveness from limited resources. The study stated:

> This requires that a methodical examination be made of alternative ways of accomplishing desirable military missions in order to select those weapons and forces which provide the greatest return for the defense dollar.[1]

The Assistant Secretary of Defense (Comptroller), Charles J. Hitch, regards all military problems as, in one of their aspects, economic problems in the efficient allocation and use of resources.[2] Today military decisions are made only after economic analysis of various alternatives.[3]

The heart of an economic analysis is the comparison of all the relevant alternatives from the point of view of the objectives each can accomplish and the costs which it involves. Appropriate economic criteria can lead to the selection of the best alternative. It must be emphasized that economic analysis

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[1]Study Report of the Programming System for the Office of the Secretary of Defense, p. II-14.

[2]Hitch and McKean, loc. cit., p. v.

[3]Program Change Control System in the Department of the Navy, p. I-1.

is a way of looking at problems which may or may not require quantitative techniques and computational devices. Complexity is usually the determining factor. It also is stressed that economic analysis does not eliminate the need for good intuitive judgement. It supplements or complements it. Judgement is always important in designing the analysis, choosing the alternatives to be compared, and selecting the criterion for comparison.[1]

The economic analysis approach can overcome the limitations of the requirements and priorities approaches. The former stresses the requirements for filling a need and budgetary aspects are considered only to prevent the generation of an exorbitant budgetary request. No explicit alternative cost or effectiveness comparisons are made. The priorities approach recognizes a budgetary limitation and attempts to rank projects by priority of need. Its major failing is its inability to rank unlike items.

The programming structure allows economic alternative cost and effectiveness comparisons of unlike items to be made. The basic building blocks of the programming system are the "program elements"--defined as an integrated combination of men, equipment, and installations whose effectiveness can be related to national security objectives.[2] For purposes of

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[1]Hitch and McKean, loc. cit., pp. 118-120.

[2]Program Change Control System in the Department of the Navy, pp. 2-3.

summarization, presentation, and comparison, program elements are grouped into "programs."[1]

> A program was defined as an interrelated group of program elements that logically must be considered together, either because they support each other or serve a common mission. The unifying principle of each program is a common mission or set of purposes for the elements involved.[2]

There are nine prescribed programs. They include:

1. Strategic Retaliatory Forces.
2. Continental Air and Missle Defense Forces.
3. General Purpose Forces.
4. Airlift and Sealift.
5. Reserve and Guard Forces.
6. Research and Development.
7. General Support.
8. Civil Defense.
9. Military Assistance.[3]

Each individual project within a prescribed program area competes on both an intraservice and interservice basis.

Relation to the Theory of Relative Effectiveness

The program structure furnishes the means to satisfy the economic theory of relative effectiveness which Lewis proposed as a foundation for his alternative budgeting theory. It attempts to attack the basic problem of comparing the different forces and projects of the individual services. It does this by comparing the relative merits of the unlike program elements toward achieving a common mission or set of purposes embodied in the programs.

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[1]The term "Program Packages" has been reduced to "Programs."

[2]Ibid., pp. 2-4.

[3]Ibid., pp. 2-11.

Decisions concerning projects are made after extensive economic analysis of cost and effectiveness of all projects within a program area. Usually a compromise between cost and effectiveness must be made. As Hitch and McKean stated:

> Neither type by itself can serve as an adequate criterion: the maximizing of gains without regard to cost or resource limitation is hardly a helpful test, and the minimizing of cost regardless of other consequences of the alternative actions is nonsense . . . . Actually, of course, it is impossible to choose that policy which simultaneously maximizes gain and minimizes cost, because there is no such policy.[1]

The compromise point is determined by arbitrary selection, or governed by other criteria. However, it is well recognized that defense budget decisions are economic decisions. As David Novick, Head of the Cost Analysis Department of the Rand Corporation testified before the Subcommittee on Economic Statistics of the Eighty-Eighth Congress:

> In summary, I do not believe the current budget to be very useful as an economic document. It would seem to me that it could be improved, first by requiring and identifying the long-range plans which are the basis for the budget. Second, by incorporating into the budget document at least 5-year projections of the funding implications of the plans. Third, by identifying specific money flows, that is, the one-time outlays such as research and development and investment, and distinguishing these from the recurring annual operating expenses. Finally, I think it is extremely important that the budget document identify current requests for investment committments and the future implications of these committments for either associated investment or recurring annual operating expenses in the years to come.
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> The present Department of Defense approach remedies these

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[1]Hitch and McKean, loc. cit., p. 165.

> deficiencies by recasting the basic objectives and their economic implications into a program budget which is prepared in addition to the regular budget. The Secretary of Defense uses the program budget as the basis for his deliberations in making his allocation of resources to the national security objectives which are his responsibility.[1]

Comparison of Costs

No perfect way for the measurement of costs exists. How can one measure the value of different input factors? The dollar comes the closest to establishing a common denominator. It reflects, to a degree, the value of alternatives that must be sacrificed. It also reflects the relative value of the different input factors.

Comparison of costs must be done on a current or future basis only. What has been spent is irrelevant for a comparison of future costs. The cost of any system is the value of future alternatives that must be sacrificed. Hitch and McKean have stated that it is only the extra or incremental cost, not historical or "from scratch" cost, entailed by each alternative system that is relevant to the comparison.[2] Although all pertinent costs are computed, only the incremental costs peculiar to each alternative are compared.

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[1]U. S., Congress, Subcommittee on Economic Statistics of the Joint Economic Committee, Hearings, the Federal Budget as an Economic Document, 88th Cong., 1st Sess., 1963, pp. 54-55.

[2]Hitch and McKean, loc. cit., p. 172.

Relation to Theory of Incremental Analysis

The cost comparison method expounded by Mr. Hitch is applied incremental analysis. The emphasis is on the additional value to be gained from each additional expenditure; it judges costs in relation to their incremental results and not on magnitude alone. Judicial application of the method should prevent the passing of the point where the phenomenon of diminishing utility is envoked. This is the essence of the theory of incremental analysis.

Budgeting

Five Year Force Structure and Financial Program

Prior to April 1962, all military projects and plans were reviewed, compared, and consolidated under the program structure. The "Five Year Force Structure and Financial Program" established, on April 25, 1962, the force structure and financial levels for Fiscal Years 1963 to 1967.[2] The FYFS and FP is the approved base plan for the five year period. Any major changes due to new or modified programs must be approved by the Secretary of Defense. Each year the plan is projected one year farther. Once the base is set, the emphasis shifts to proposed and actual changes. Cognizant Congressmen are aware of and involved in the approval of the FYFS and FP. However, the

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[1]Hitch and McKean, loc. cit., p. 172.

[2]Program Change Control System in the Department of the Navy, p. 3-1.

annual budget request is still submitted in the traditional form.

Program Change Control System

As previously mentioned, program change proposals must be submitted to SECDEF whenever the changes exceed certain "threshold" amounts established for the various cost categories. For example, changes in excess of $10 million for one year or $25 million for all years for research and development programs must be approved by SECDEF. The purpose of the program change control system is to:

1. Combine all existing channels for major decision making into one;
2. Provide better information for decision making purposes;
3. Ensure that each program change proposal is referred for decision to the proper level in the OSD;
4. Ensure rapid, but complete, review of proposals by the DOD components concerned;
5. Ensure that current and budget year decisions are made in the light of their future year efforts and overall Defense requirements;
6. Permit the maintenance of an up to date five-year approved program.[1]

Examination of the system purposes indicates that all proposals are examined from the cost, effectiveness, and budgetary viewpoints. As Mr. Hitch was quoted in describing the fundamental objective of the system:

> . . . to create a planning and programming/financial management system that is keyed to continuous program decision-making and not just geared to the annual budget cycle.[2]

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[1] Ibid., p. 4-1.

[2] Ibid., p. 1-1.

In essence, budget decisions are made any time a program or change decision is made. Can it be said that this emphasis on change analysis is, in effect, incremental analysis? I believe that this is the only logical interpretation of the purposes of the system.

Factors Causing Change

Changes are encouraged and required. A change may be generated by such things as new plans, technological breakthroughs, revisions in military policy, changes in the assessment of the enemy threat, changes in program emphasis, previous faulty judgement, etc.[1] Broadly speaking, these changes are generated within the realm of the Secretary of Defense.

The pressure for some changes may arise from areas other than military requirements. The magnitude (56% of total budget)[2] of the defense budget proposed for fiscal year 1965 makes it a major instrument of fiscal policy. It has been stated that:

> To be sure, defense is not the greatest prop or force in the U. S. economy, as it is sometimes assumed. The cutbacks in 1957 did not cause the recession. But they did contribute to its severity. From mid-1957 to the first quarter of this year, the Defense Department reduced its annual spending rate by $2 billion--more than two-thirds of the cut was in procurement--and this touched

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[1] Ibid., p. 4-1.

[2] U. S., Bureau of the Budget, The Budget in Brief for Fiscal Year 1965, pp. 26 and 81.

> off an additional $2 billion decline in the rate of inventory purchase by aircraft and other contractors. And the psychological effects were even more severe. When the cutbacks were made, it was widely assumed that tax reduction would follow. Instead, the Soviet Union's startling success in rocketry shelved the plans for tax reduction while not immediately increasing military orders the result was a sharp decline in business expectations.[1]

Since national fiscal policy is developed primarily through the national budget process, the size of the defense budget makes it a major fiscal tool.

A national budget reflects more than just fiscal policy. It also reflects:

1. The will of the people on the spending issues before the Congress.
2. The legislative frame-of-mind which often puts local concerns ahead of national ones.
3. The question of whether the proposed public services meet the national needs.[2]

These three considerations are determined by personal desires which are subject to the mood and temperment of the moment and are highly variable.

The relationship of the defense budget to the national budget indicates that the defense program must be considered and harmonized with the overall economic and fiscal policies. It also follows that since the budget is a flexible instrument of economic policy,[3] the defense budget itself must be receptive to

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[1]C. E. Silverman and S. S. Parker, "The Economic Impact of Defense," Fortune, June 1958, p. 103.

[2]Maurice H. Stans, "The Federal Budget--The Deeper Issues," The Journal of Accountancy, May 1959, pp. 32-33.

[3]Ibid.

orderly change.

It has previously been shown that although the budget is prepared on a program basis within the Department of Defense, it is still submitted to the Congress in the traditional classifications format. The five classifications used for congressional consideration are: Personnel, operations and maintenance, procurement, research and development, and military construction. Neither basis contains any information for easy Congressional "trade-offs" between programs or any degree of built-in flexibility.

The congressional trade-off informational need is not as important as it seems. In actuality, ranking members of cognizant congressional committees are kept informed of what is taking place and why in the military establishment. To quote Rear Admiral M. L. Hirsch, USN: "Under the new setup, we spend more time on the hill and keep the congressmen informed.[1] It can then be assumed that the Congress is aware of the basis for DOD decisions before it nods its approval. No information for trade-offs between defense and non-defense programs is possible. Only the defense budget is formulated on an economic basis.

Nevertheless, the defense budget should possess a built-in degree of flexibility if it is to reflect its position as a major tool of national fiscal policy and be able to respond to

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[1]An Address by RADM M. L. Hirsch, USN, to the Navy Graduate Financial Management Class, The George Washington University, on February 5, 1964.

the other budgetary influences. At present the only major means of modification are the program changes. Regardless of the possible existence of contingency plans to reflect nonmilitary actions at the DOD level, the writer has found no method for the pre-planned guidance of the individual bureau or office to smoothly respond to budgetary changes.

Budget Preparation

The budget document is very important for the planning, guidance, and control of a services program. The Navy has described it as:

> . . . the one document in the Navy which sets forth clearly and precisely each year what the Department's level of effort will be and what it expects to accomplish. The budget also serves as a control device during the year in the execution of programs. Thus, the budget is an operating vehicle under which the annual planning and execution of programs is carried out. As such, it is a document of utmost importance to the welfare of the Department and to the Nation as a whole.[1]

Since the Five Year Force Structure and Financial Plan has set the level of effort for the included years, departments can develop their annual budget request from the budget year of the plan. Mr. Hitch described the process as follows:

> By its nature, the budgeting phase is an annual operation, taking place in the fall of each year in phase with the overall financial cycle of the Government as a whole. It does not interfere in any way with the programming process or with our continuing consideration of the longer range problems of defense, since, in essence, we simply take the next annual increment of the programs as the basis for the

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[1]U. S., Department of the Navy, Office of the Comptroller, The Budget Process in the Navy, October 1959, p. 1-9.

budget, thus financing the longer range program on an annual basis.[1]

The FYFS and FP does not make the annual budget process a fixed proceedure. SECDEF issues guidelines based upon the guidelines set forth by the President and those recommended by the Joint Chiefs of Staff. In addition, he issues certain basic assumptions and fiscal guidelines.[2] These may cause a major variance from the annual increment of the plan.

The budgetary phase is where the details of the overall program concept are settled. The actual budget preparation process, although simpler, is conducted in the traditional manner. As Mr. Hitch stated:

> The budgetary phase of the planning-programming-budgeting process is, and will continue to be, conducted in pretty much the same manner as in the past, jointly with the Military Division of the Bureau of the Budget. It is in this phase that we scrutinize most closely such things as production schedules, prices, lead-times, activity rates, personnel grade structures, training requirements, funding problems, etc. It is during this phase that we have to settle on detailed shopping lists for missiles, aircraft, guns, and all the thousands of individual items of equipment and supplies for which we will request appropriations in the next fiscal year. And it is during this phase that the final adjustments are made in the programs to be financed during the coming fiscal year.[3]

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[1] An Address by Charles J. Hitch, Assistant Secretary of Defense (Comptroller), at the 22nd National Meeting of the Operations Research Society of America, Philadelphia, Pennsylvania, Nov. 7, 1962, (in the library of the Bureau of the Budget), p. 16.

[2] U. S., Department of the Navy, Bureau of Naval Personnel, Financial Management in the Navy, NAVPERS 10792-A, March 23, 1962, p. 48.

[3] Charles J. Hitch, loc. cit.

The budget preparation phase is where the plans and programs take their first step toward reality. It is where resources are applied to requirements. It is where the level of effort is specified in detail for all cognizant activities. It is where the program objectives--the increments of major programs which are feasible of accomplishment during a year[1]--are prepared and costed.

Budget Review

The purpose of budget review is to apply the concept of relative value to the competing proposals made within a broadly defined program. Review levels range from the internal service departments or bureaus to the President. At each level the reviewer is concerned with the problems applicable to his level in the hierarchy. As the budget proceeds through the structural framework, a continuous "boiling-down" process occurs. A Navy budget receives a minimum of eight distinct reviews before it is submitted to the Congress for further review and approval.[2] When the budget arrives at the Congress it is a financial report that expresses the President's present and future priorities.

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[1] Financial Management in the Navy, p. 48.

[2] For a more detailed description of the process see Financial Management in the Navy, pp. 49-58.

CHAPTER III

PERT

Definition

PERT is a management planning and control tool which is used for defining, integrating, and interrelating what must be done to accomplish program objectives on time. It has been officially defined as:

> . . . a set of principles, methods, and techniques for effective planning of objective oriented work thereby establishing a sound basis for effective scheduling, costing, and replanning in the management of programs.[1]

Statistical methods are the basis for the diagnostic and prognostic techniques used to quantify the many uncertainties faced in meeting program deadlines. PERT can focus the attention of management on program areas that appear to be heading for trouble. It enables the manager to effect a priori adjustments in time, resources, or technical performance to maintain or to improve the ability to accomplish program objectives on time. In essence, PERT is a real-time decision making tool.

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[1]U. S., PERT Coordinating Group, PERT Guide for Management Use, June 1963, p. 3.

Development Of PERT/TIME

The technological explosion that occurred from 1945 to 1958 brought major changes in military weapons and the support systems necessary to back them up. Management techniques failed to keep abreast of the technological advances. Government recognition of the problem that existed, and still exists to a great extent, is evidenced in a management improvement report which states:

> The technological explosion has spawned a need for new management techniques but has not automatically generated them. Indeed, management breakthroughs have been harder to come by, as a rule, than technological advances.[1]

As the state of technology advanced, research and development programs became increasingly massive and expensive. It was recognized that management's failure to maintain pace with the technicians could have far reaching effects:

> Management mistakes and omissions can be costly in terms of men, money, and materials . . . . These decisions . . . are intimately related to our national security.[2]

Increased emphasis was placed on efforts to seek a management breakthrough.

The U. S. Navy's Special Projects Office established an operations research team in 1958 to search for better ways to manage the development of the POLARIS Fleet Ballistic Missle

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[1]U. S., Executive Office of the President, Bureau of the Budget, Cost Reduction Through Better Management in the Federal Government, 1963, p. 37.

[2]Ibid.

Weapon System. The team realized that they needed three kinds of data in addition to that furnished by existing systems. They wanted data to:

1. Assess the validity and reasonableness of plans and schedules for carrying out a program and meeting objectives.
2. Measure progress in research and development.
3. Predict the outlook for meeting the objectives.[1]

The team also realized that the interrelation and integration of the factors of time, resource applications, and technical performance were the keys to program management success. The operations research team devised a system to measure one of the factors (time) to represent all three. It was called the PERT system. Later developments caused this original system to be known as PERT/TIME.

Applications

The spectacular success of the PERT system in the development of the POLARIS program focused international attention on the technique. Within the government, the PERT system has been successfully applied to weapon and space systems acquisition, missle site activation, atomic energy programs, civil defense programs, maintenance planning, training programs, etc.

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[1]Willard Fazar, "Navy's PERT System," The Federal Accountant, December 1961, p. 126.

Business enterprise was quick to get aboard the bandwagon. Industrial giants such as DuPont and General Electric quickly adapted the system for nondefense programs. PERT has been used for construction projects, theatrical productions, new product introductions, advertising campaigns, and book publishing. Although the degree has varied, substantial savings occurred wherever the system was properly applied and efficiently administered.

PERT is an effective management planning and control tool for most nonrepetitive projects. PERT projects must have the following characteristics:

1. The project consists of a well-defined collection of jobs which, when completed, marks the completion of the project.
2. Within a given sequence, the jobs may be started and stopped independently of each other.
3. The jobs are ordered--i, e., they must be performed in technological sequence.[1]

Repetitive projects are more efficiently managed by other techniques.

Features

There are four salient features of the PERT system. They are planning, scheduling, the concept of critical path, and real time management. In a broad sense, planning and scheduling constitute the planning phase, and the control phase is

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[1]F. K. Levy, G. L. Thompson, and J. D. West, "The ABC's of the Critical Path Method," Harvard Business Review, Sept.-Oct. 1963, pp. 98-99.

composed of the concept of the critical path and real time management.

Planning

Once a goal has been determined, the next step is the development of a plan to set forth the nature, sequence, constraints and interrelationships of the events which must be accomplished to attain the goal. These identifiable events must then be linked so as to graphically portray the interdependence among them.

To understand PERT planning one must be familiar with the following terms:

> Activity: a time-consuming element in the development program. It is represented on a network by an arrow.
> Constraint: the relationship of an event to a succeeding activity that cannot start until the event has occurred.
> Event: a meaningful specified accomplishment in the program. It is represented on a network by a circle. It is a point in time.
> Milestone: a synonym for event.
> Network: the diagram of events, activities, and time estimates which represent the program.
> Preceeding Event: an event must be completed before the following activity can be started.
> Succeeding Event: an event that cannot be accomplished until the preceeding activity is complete.[1]

When these terms and the information that gives meaning to them are known, it is possible to construct a network.

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[1]From a Management Glossary issued by Dr. Richard F. Ericson, Professor of Business Administration, The George Washington University, to the Navy Graduate Financial Management Class, December 1963, for Business Organization and Management, BA-263.

First it is necessary to know some ground rules. They are:

1. Each arrow should represent only one activity.
2. The length of the arrow has no significance.
3. Each activity except the first must have an activity preceeding it.
4. Each activity except the last must have an activity following it.
5. For any activity to begin, all preceeding activities must be completed.
6. No two activities can have the same origin and ending.[1]

Assume that higher authority has selected the development of an airborne radar set as the objective. The first task is to determine the major areas of endeavor that will contribute to the objective. Each functional area of activity--analysis, design, drafting, mock-up, fabrication, environmental test, and flight test--should be listed. Next, the major events during the program must be determined.

The actual construction of the network is shown in Figure 1. The ending event--completion of a tested prototype model--is placed at the right margin. Determine the major event or events that must be completed just prior to attaining the objective. These are preceeding events and are placed adjacent to the end objective. Due to program time considerations, it is necessary to perform some of the activities simultaneously. The environmental test activities and the fabrication and flight test activities illustrate the construction of parallel activities and events to depict the situation. The network

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[1]Sidney I. Neuwirth and Joel Zelnick, "Introduction to PERT," The Journal of Accountancy, May 1963, p. 84.

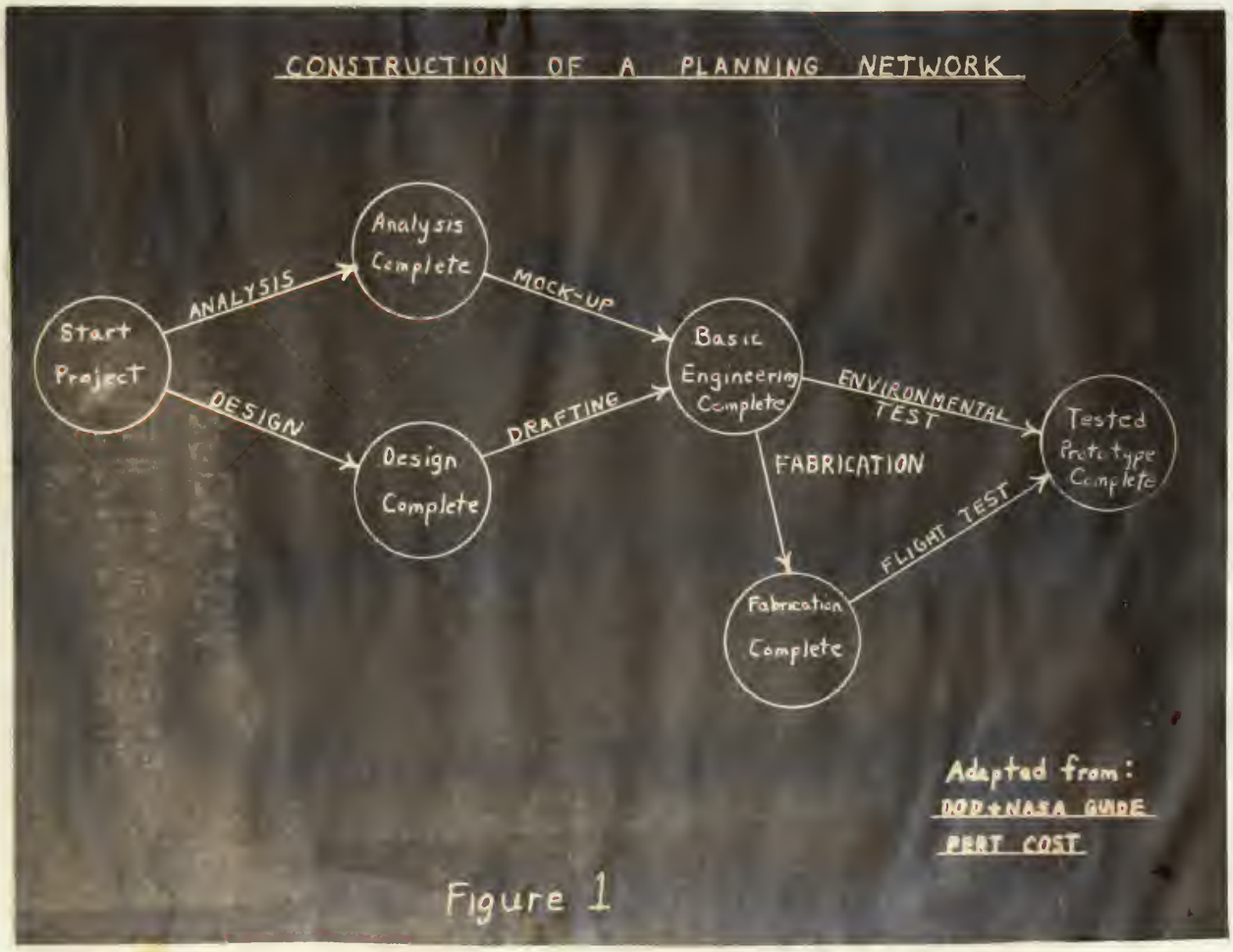
CONSTRUCTION OF A PLANNING NETWORK
Start Project
ANALYSIS
Analysis Complete
MOCK-UP
DESIGN
Design Complete
DRAFTING
Basic Engineering Complete
ENVIRONMENTAL TEST
FABRICATION
Tested Prototype Complete
FLIGHT TEST
Fabrication Complete
Adapted from:
DOD+NASA GUIDE
PERT COST

Figure 1

construction process continues with each event being attached to its preceeding event until the starting event is reached.

After the planning network is completed it must be reviewed to insure that it represents a logical development of the task. It must also be checked to guarantee compliance with organizational proceedures or one must be changed. It is important to note that planning networks are constructed to satisfy the requirements of all managerial levels. The project planning network of Figure 1 could contain many subcharts. These subnetworks set forth the kind, quality and quantity objectives for the work to be performed at each level.

Scheduling

When the planning network is satisfactorily constructed, the next problem is the estimation of the time required to proceed from event to event with an estimate of the uncertainties that are involved. This is the scheduling function. Knowledge of the following terms is necessary for a basic understanding of the scheduling process:

Activity times: estimates of the time required to complete an activity in a specified manner. Three estimates of activity time are utilized. They are:
(1) Optimistic time: the time needed if everything goes exceptionally well. The odds are 100:1 against.
(2) Realistic time: the time needed if things proceed normally.
(3) Pessimistic time: the time needed if everything went wrong, barring acts of God.

Directed date: a date set by superior authority for a specific accomplishment.

Expected time: the predicted time required for an

activity. It is derived from the calculation of a statistically weighted average time estimate which considers the optimistic, realistic, and pessimistic time estimates.

Expected date: obtained from the starting date of the initial event by adding the expected times from the initial event to the event considered.

Latest date: the date by which a given event must be completed to allow the program to be completed on schedule.

Slack: the time difference between the latest and expected dates for an event. If the expected date is earlier than the latest date, the slack is positive. If the expected date is later than the latest date, the slack is negative. Identical dates produce a zero slack condition.[1]

Sceduling is the translation of a plan, with its elapsed time estimates, into calendar.

Assume that the activities portrayed in Figure 1 had the optimistic, realistic, and pessimistic time estimates listed in Table 1 assigned. The expected times listed were computed by use of a formula derived by the PERT research team. Figure 2 illustrates the time schedule superimposed on the planning network. The three time estimates are shown above the arrow depicting each activity, and the expected time is given below the arrow. Analysis of all possible start to finish paths reveals that the longest path requires 20.5 weeks. If this results in a completion date later than the desired date, the plan must be adjusted. If adjustment is not possible, the completion date must be delayed.

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[1]Ericson, Management Glossary, op. cit.

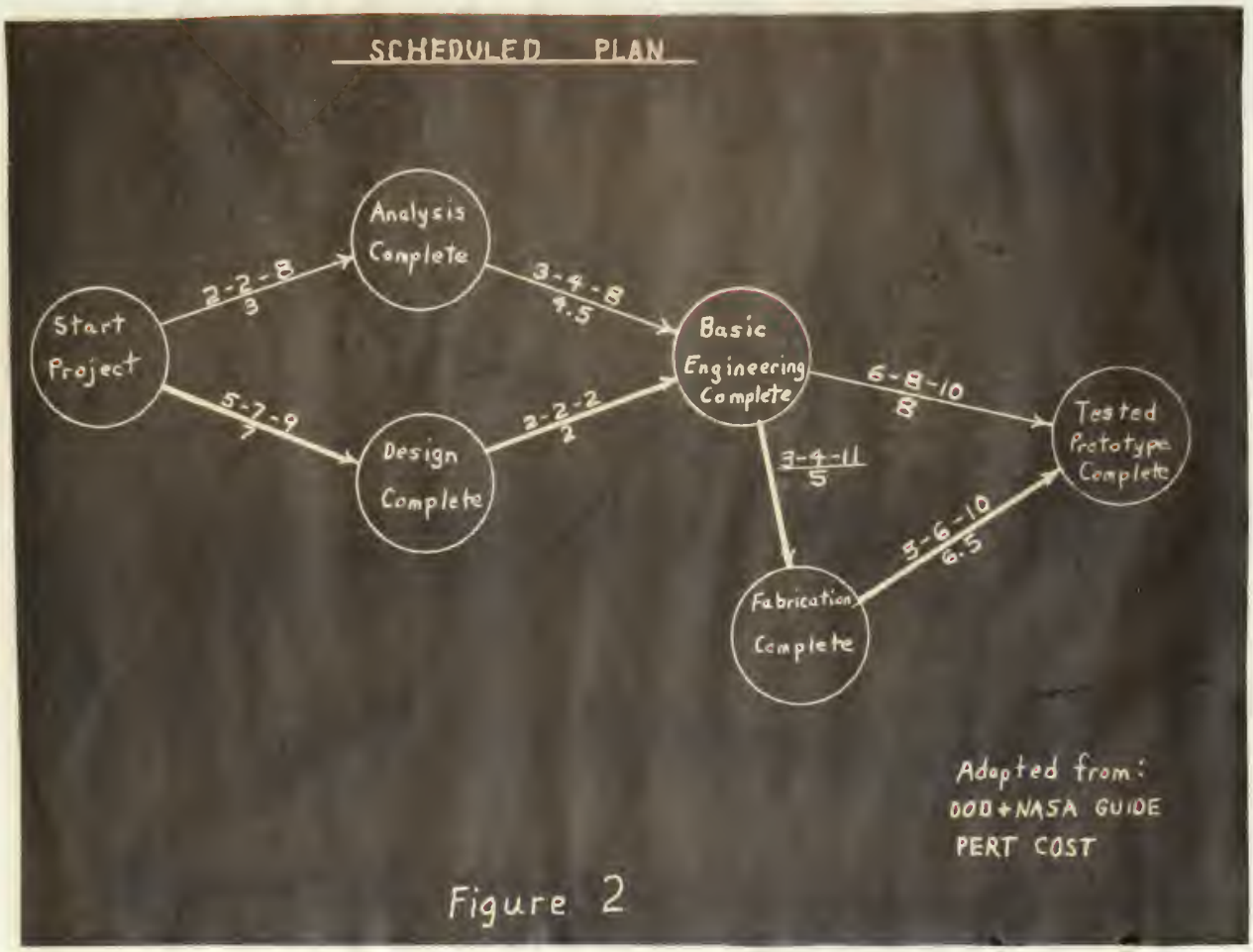
SCHEDULED PLAN
Start Project
Analysis Complete
Design Complete
Basic Engineering Complete
Fabrication Complete
Tested Prototype Complete
2-2-8
3
3-4-8
4.5
5-7-9
7
2-2-2
2
6-8-10
8
3-4-11
5
5-6-10
6.5
Adapted from:
DOD + NASA GUIDE
PERT COST

Figure 2

Concept of the Critical Path

The purpose of the technique is to systematically highlight the degree of criticalness for each event. The

TABLE 1

TRANSLATION OF TIME ESTIMATES (weeks)

Activity	Optimistic Time	Realistic Time	Pessimistic Time	Expected Time
analysis	2	2	8	3
design	5	7	9	7
drafting	2	2	2	2
mock-up	3	4	8	4.5
fabrication	3	4	11	5
environmental test	6	8	10	8
flight test	5	6	10	6.5

critical path is the sequence of interconnected events and activities between the start of a program and its completion, which will require the longest time to complete. It is the longest path in the network, and it has the greatest negative or least positive slack. It is the path which must not be allowed to fall behind schedule. In Figure 2 the critical path is depicted by the broadest line.

Real Time Management

The scheduled plan is management's blueprint for success. To ensure the success of the plan, the PERT system has developed reports to yield data on actual versus scheduled plans. The

volume of reports is reduced by use of the management by exception principle. Only deviations from the current or scheduled plans are reported. The manager requires a detailed analysis on the specific problem only.

Performance forecasts, the concept of the critical path, and the principle of slack combine to make real time management possible. If trouble is envisioned along a noncritical path, no action may be necessary if the delay does not cause the latest date for the path to be later than the network's expected date. Forecast trouble on the critical path requires corrective action before it occurs. The usual solution is to "trade-off" some of the resources which were to be applied to noncritical activities and would have resulted in positive slack for the path. Enough of the resources would be transferred to the critical path activities to allow them to maintain their schedule. However, too many resources cannot be removed from the noncritical paths, or they will become critical paths.

Analysis of the effect of proposed changes on the scheduled plan allows management to view their effects prior to their occurrence. This is before-the-fact or real time management.

Advantages Of PERT

The system discussed so far is the one originally designed by the PERT research team. It used time as the common denominator for all of the factors affecting program management

success. The resource allocation and technical performance factors were secondary. This original approach is now known as PERT/TIME.

A principal advantage of PERT is forced planning by management. To realize the advantages of the system it is necessary to analyze, plan and schedule each step from project commencement to completion. It forces management to focus their attention on planning and control. Jobs critical to project completion time are highlighted for special attention.

Real time management is another benefit of the system. Action can be taken a priori rather than a posteriori. When computers are used, cybernetic management results. The effects of decisions can be simulated in advance.

A third major advantage of PERT is improved control and evaluation. Planning and performance cannot be disassociated. Since performance estimates are prepared by the technicians, they are aware that management--for the first time--has an objective yardstick for professional evaluation.

PERT furnishes an effective method of communicating plans and their substance. It fulfills the four functions of administrative communication; to inform, to evaluate, to instruct and to influence. The system aids two of the three basic management functions--decision making and communicating. Only leadership is missing and management can evidence that by effective implementation of the system.

Finally, the system introduces an integrated methodology into the realm of program planning. It has been said that simplification of complexity is necessary for progress:

> Our progress depends to a considerable extent on seeing to it that simplifying processes move forward in approximate balance with the complicating process. If this can be accomplished, then individuals with given ability can expect to go forward indefinitely without becoming casualties of their own complexities.[1]

It will be seen that further developments of the PERT system produce more order from complexity.

Limitations Of PERT

Although the three time estimates are used in an attempt to arrive at a statistically correct activity time, the basis for all the estimates is subjective. Is a statistical adjustment for three guesses better than a single guess? The answer is not definitely known today.

PERT does not correlate progress and expenditures. It considers time only. It implies that resources are available and switchable. PERT/COST discussed next, overcomes some of these difficulties.

Because it requires comprehensive detailed planning and scheduling, the overhead costs generated by PERT are higher than

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[1]Zay Jeffries quoted by Ralph J. Cordiner, New Frontiers for Professional Managers, New York: McGraw-Hill Book Company, Inc., 1956, p. 95.

for other planning and control systems. If it is properly used on an applicable program, and if it is integrated with--not added to--existing systems, the benefits gained will outweigh the increased costs.

Development Of PERT/COST

PERT made a major contribution to the management planning and control of complex programs. It was designed for the Fleet Missle Program, a program which was assigned a national priority.[1] Consequently, time was the primary consideration and resource limitations were secondary. Although resource application and control is implicit in the PERT system, much of the control is lost under dynamic conditions. Management had to use static cost controls for dynamic planning and scheduling.

Conventional cost control approaches emphasize cumulative costs in their cost versus time projections. It is possible for a program to be close to its cost schedule when cumulative costs are used and still be in very serious trouble. If one portion of a project involved a large cost overrun and another a substantial underrun, one would tend to cancel the effect of the other. However, underruns usually occur due to schedule slippage and not due to a reduction of total production costs. The work required by the lagging activities still must be

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[1]From an Address by Captain John K. Leydon, USN, to the Navy Graduate Financial Management Class, The George Washington University, October 15, 1963.

performed. When it is done, the project will incur a total overrun cost.

The original PERT research team realized that the program network might provide an ideal framework for the development and control of costs on complex programs. However, they decided the problems of implementing PERT were enough for one time. Even today, it is doubtful that any organization can successfully implement PERT/COST unless it has had PERT experience.[1]

The Department of Defense worked on the network cost/time relationship concept in conjunction with Management Systems, Inc. of Cambridge, Massachusetts. In June 1962, the Federal government set forth the requirements of the basic PERT/COST system. The requirements were personally endorsed by the Secretary of Defense and Associate Administrator of the National Aeronautics and Space Administration. This brought about a degree of conformity and uniformity among a large segment of American Industry. Just within the Navy Department, PERT/COST has been applied to programs totaling approximately one billion dollars.[2]

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[1]Robert W. Miller, Schedule, Cost, and Profit Control with PERT, New York: McGraw-Hill Book Company Inc., 1963, p. 90.

[2]From a Telephone Conversation with Mr. Arthur C. Gehringer, Navy Representative on the Department of Defense PERT/COST Steering Committee, on February 18, 1964.

PERT/COST is an integrated management planning and control system. The two basic objectives of the system are to achieve more realistic original program cost estimates and to achieve better control of performance against the estimate. It is designed to blend with existing management systems and to provide important additional data. Two supplements to the system have been designed and will be discussed later.

Features

In addition to the features of PERT, there are two salient features of PERT/COST. They are the total cost concept and the cost work package.

Total Cost Concept

A major difference between PERT and PERT/COST is the level of detail involved. Networking of PERT programs was applied only down to the levels which were thought to have an effect on the schedule outcome. Networking for PERT/COST programs must be very complete in order to include all activities which generate a direct cost to the programs. For exact and comprehensive planning and control, it is necessary to consider the total cost of the program. To consider only apparent costs may be deluding and/or irresponsible.

The concept of total cost includes direct, nondirect, and penalty costs. Direct costs are those that vary directly with time and are specifically identifiable with the program. The

cost of program management may be considered a direct charge. Nondirect costs are those which occur regardless of the program in progress. Overhead is the most common nondirect cost. A portion of the nondirect costs must be assigned to all "in house" programs. Penalty costs may be considered to represent the loss of profits resulting from lack of plant capacity, down time, or competitors products.

Consideration of the effect of these individual and cumulative costs over a time period can radically change optimum project completion times. The following discussion is based on Miller's assumptions of the time-cost relationships for a job.[1] In Figure 3, curve A represents the empirically derived direct cost-time relationship. It commences at the first possible time the project could be completed regardless of the money and manpower involved. This point is called the crash point. The curve point corresponding to the lowest cost yields the optimum time to complete the project, at minimum cost, if only direct costs are considered.

If nondirect costs (curve B) are considered, the optimum time-cost point will change. Curve B depicts the linear relationship between nondirect costs and time. To consider the effect of both direct and nondirect costs, curve D is drawn. It represents the sum of curve A and curve B at each increment of time. The second optimum time-cost point has shifted to

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[1]Miller, loc. cit., pp. 123-125.

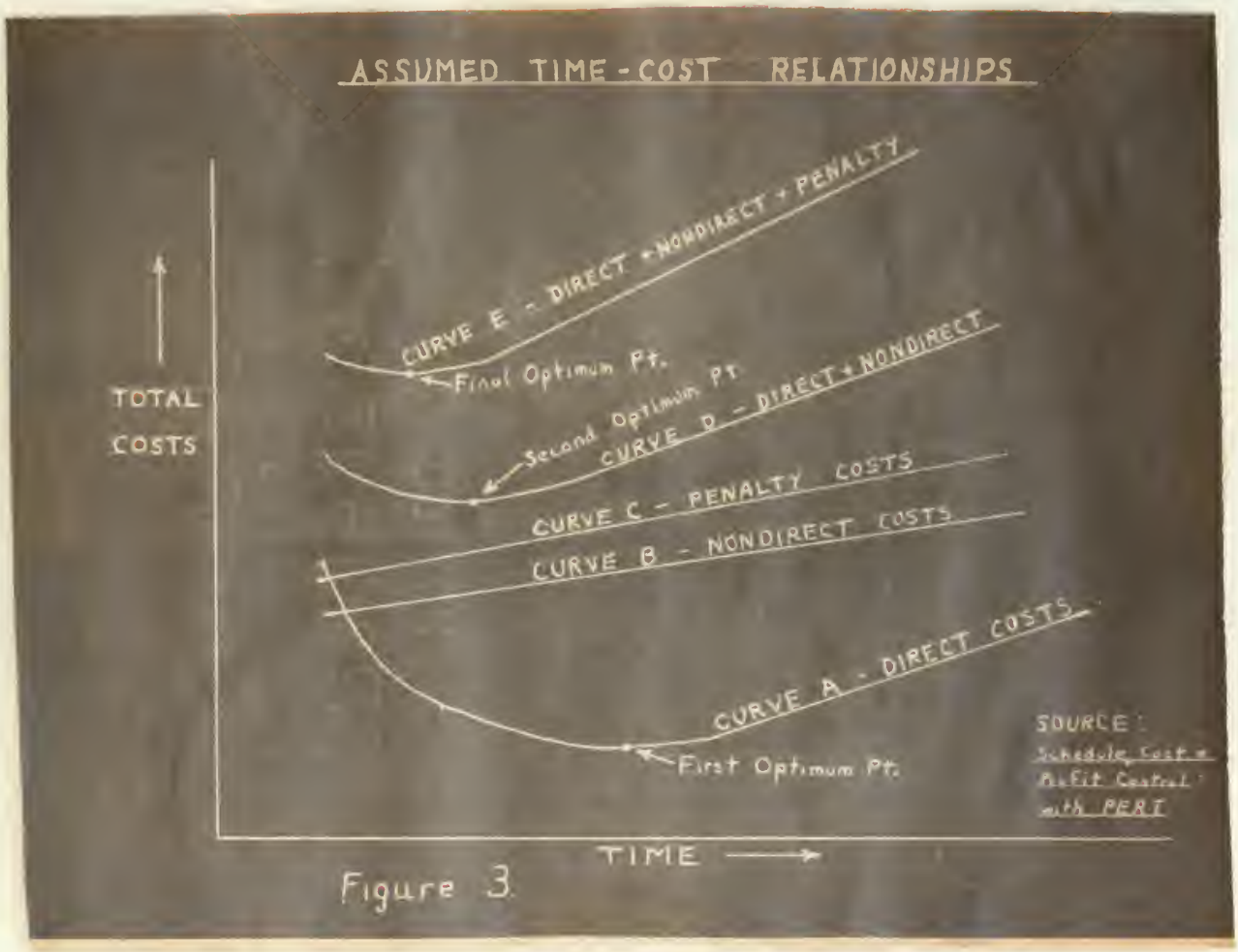
ASSUMED TIME-COST RELATIONSHIPS
TOTAL COSTS
CURVE E - DIRECT + NONDIRECT + PENALTY
Final Optimum Pt.
Second Optimum Pt.
CURVE D - DIRECT + NONDIRECT
CURVE C - PENALTY COSTS
CURVE B - NONDIRECT COSTS
CURVE A - DIRECT COSTS
First Optimum Pt.
SOURCE: Schedule, Cost & Profit Control with PERT
TIME

Figure 3

require less project time. It must be remembered that although the optimum time period is shorter, a higher level of activity will be required to complete the project in the shorter time.

Penalty costs are shown in curve C. The resultant of the direct, nondirect and penalty curves is plotted on curve E. The third optimum point requires the shortest time period and the highest activity rate of all.

From examination of Figure 3, it is obvious that the analyst who fails to consider all costs is lucky if he selects the correct time period for project completion. Each cost involved directly affects the position of the optimum time-cost relationship. Only careful analysis of all costs will lead to the selection of the proper point.

This discussion has assumed that lowest total project cost was the prime objective of the analyst. This is not always the case. Sometimes time may have a greater importance than minimum project cost. At other times the reduction of project risk may be paramount. The concept of penalty cost attempts to quantify the losses which may occur from nonconsideration of the time and risk factors. However, it does not furnish management with information for selection of an alternative more suitable to their needs. The time-cost option supplement to PERT/COST does furnish this.

Cost Work Package

To provide a framework for the complete networking of PERT, the analyst used the concept of a product oriented Work

Breakdown Structure. To implement the decisions of management, which may be based on upper-level charts (Figures 1 and 2), it is necessary to descend to the levels that present meaningful physical end items for networking. In other words, the implementation must be made at the point where the emphasis shifts from planning and control to the product itself.

A simplified Work Breakdown Structure is presented in Figure 4. It is available and useful to all levels of management, but it has its greatest utilization at the working or implementation stage. It is at this level that a time and cost correlation can be established for tasks. The correlation was implied for PERT but it is explicit for PERT/COST. Cost elements such as man-hours, types and degrees of skills, and outside material dollars are required for the latter system.

The magnitude of the accounting problem involved if each individual activity on the working level had a separate costing account would be staggering. The law of diminishing returns would be invoked and the benefits of the system would be negated. The Government recognized the problem and permitted the activities of the network for the lowest level of work breakdown to be grouped together in work packages. The DOD/NASA guide stated:

> The Work Packages formed at the lowest level of breakdown, then, constitute the basic units in the PERT/COST system by which actual costs are (1) collected and (2) compared

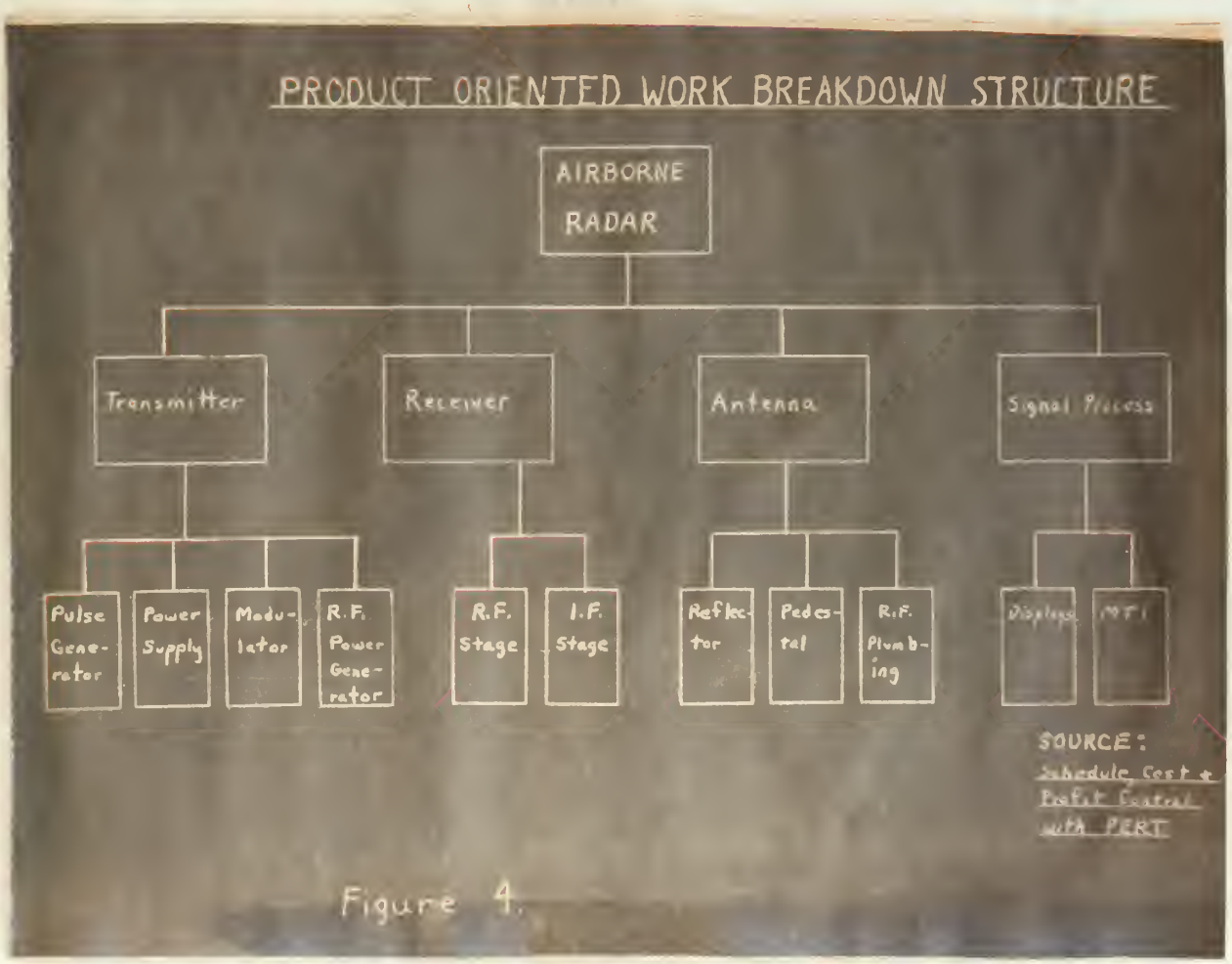
PRODUCT ORIENTED WORK BREAKDOWN STRUCTURE
AIRBORNE RADAR
Transmitter
Receiver
Antenna
Signal Process
Pulse Generator
Power Supply
Modulator
R.F. Power Generator
R.F. Stage
I.F. Stage
Reflector
Pedestal
R.F. Plumbing
Displays
MTI
SOURCE: Schedule, Cost & Profit Control with PERT

Figure 4.

with estimates for purposes of cost control.[1] As a rule of thumb, the guide stated that the Work Packages should be no longer than three months duration and $100,000 in cost. Factors such as the industry involved, size of the program and existing accounting systems will determine the exact size and duration of the Cost Work Packages.[2]

Figure 5 depicts a Work Package breakdown that could exist on the operating level network for the design of a power supply of our hypothetical airborne radar set. The network is overly simplied. In actuality, each activity would have a time and cost estimate listed. Each completed activity would have the actual time and cost figures listed.

Impacts Of PERT/COST

PERT/COST amplifies all of the advantages and characteristics of PERT. By adding the dimension of cost, the manager is able to do a better job of planning and to exercise a greater degree of meaningful control.

The improved planning and control tend to emphasize the impact of the system on the organization. The cutting of the traditional organizational lines is more apparent with PERT/COST than with PERT/TIME.

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[1]U. S., Office of the Secretary of Defense and National Aeronautics and Space Administration, DOD and NASA Guide: PERT COST, June 1962, p. 29.

[2]Ibid.

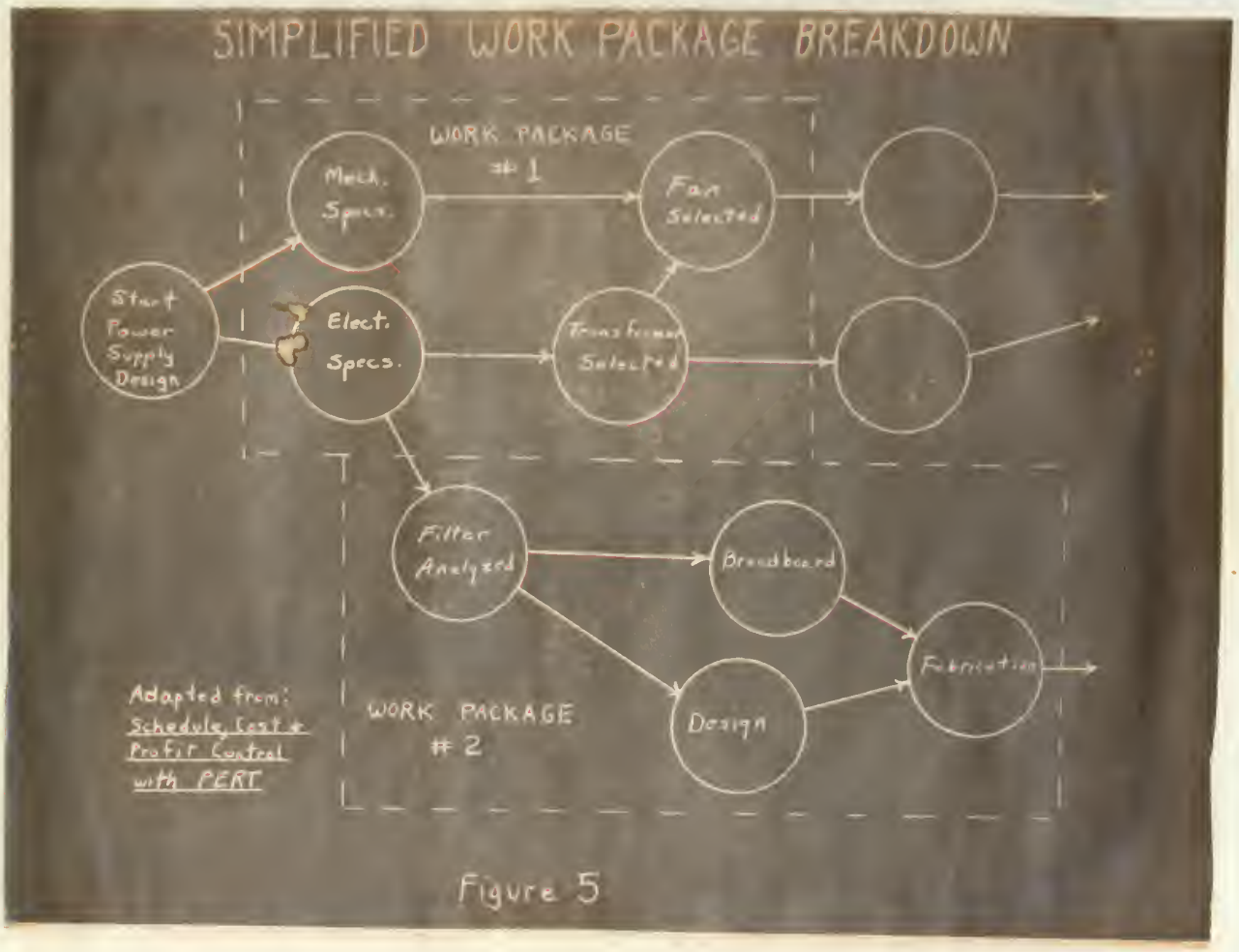
SIMPLIFIED WORK PACKAGE BREAKDOWN
WORK PACKAGE #1
Mech. Spec.
Part Selected
Start Power Supply Design
Elect. Specs.
Transformer Selected
Filter Analyzed
Breadboard
Fabrication
Design
WORK PACKAGE #2
Adapted from: Schedule, Cost & Profit Control with PERT

Figure 5

The addition of the cost dimension increases the overhead costs from those incurred under a PERT system. The added cost is not considered to be any more than would be incurred if any comprehensive cost control system were installed. As with PERT, the additional benefits generated by PERT/COST outweigh the increased costs.

CHAPTER IV

SUPPLEMENTS TO PERT/COST

PERT/COST Extensions

The PERT/COST System provides a management planning and control tool to utilize available resources and time to meet the objectives of a project. However, it does not indicate if the optimum balance of time, cost, and risk necessary to meet the objectives currently exists. Neither does it indicate if maximum efficiency of resource utilization will be realized. To overcome these deficiencies, two supplemental extensions to PERT/COST have been developed. These are known as the Time-Cost Option Supplement and the Resource Allocation Supplement.[1] The latter is designed to indicate whether a substantially more efficient alternative may exist. It is beyond the scope of this paper. The Time-Cost Option Supplement develops alternative plans to afford a selection which emphasizes the desired weight of time, cost, or risk.

Time-Cost Option Supplement

The date selected for the completion of a project is usually the result of an evaluation of the military need, cost,

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[1]DOD and NASA Guide: PERT COST, pp. 99-124.

and risk involved. Examination of the interrelationships involved has been inherent in military planning. Captain Gumz indicated this in 1959, when he said:

> The military planner developing force requirements must have an accurate and specific goal in mind. He must be aware of the relative costs of meeting that goal by means of the various weapons systems available to him.[1]

The fact is that, in the past, the evaluations of the interrelationships has been more implicit than explicit. Growing complexity prevented complete examination and PERT, a simplifier of complexity, considers only the use of resources to complete a project in the desired time.

Time may be gained or lost if the project received more or less money than was requested to meet the desired completion time. Conversely, a major saving may result if a program's contract time were prolonged. Cost is a major variable in program completion and the effects of varying this parameter should be examined.

Risk must be determined and weighed prior to commencement of a project. It may have a military or technical basis, or both. Time appears to be proportionate to risk. However, depending on the basis, it may be a direct or inverse relationship. The more time spent on a project probably decreases the technical risk of failure. Conversely, the more time spent on a project may increase the military risk of the

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[1]Donald G. Gumz, "The Bureau of the Budget and Defense Fiscal Policy," United States Naval Institute Proceedings, April 1959, p. 89.

consequences of not having the end product. Cost does not appear to have any direct relationship to risk. Figure 3, page 55, illustrates that an optimum cost-time point exists for each program. Before this point, costs are higher due to the increased rate of resource application. Beyond the point, fixed charges cause total project costs to rise. The optimum time-cost date may not reflect military and/or technical risk. Since costs ride on both sides of the point, no direct relationship exists between cost and risk. Nevertheless, a definite interrelationship does exist between time, cost, and risk.

The Time-Cost Option Supplement provides information for examination of some of the aspects of the cost, time, and technical risk relationships. The supplement uses the same time and cost estimates that are required to develop the basic, or "Directed Date Plan," in order to develop two additional plans. The only additional time and cost estimates required are for new activities or modified activities required by the alternative plans. The alternative plans are known as the "Most Efficient Plan" and the "Shortest Time Plan."

Directed Date Plan

The plan developed to meet the technical requirements of a project by a given date is the Directed Date Plan.[1] As previously discussed, the date is selected after consideration

[1] DOD and NASA Guide: PERT COST, p. 102.

of the military risk and cost involved. This plan is the base plan upon which the alternatives are developed. Since the alternative plans do not consider military risk, their effect upon military risk is implied by the changes proposed in cost, time, and technical risk. Figure 6A represents a hypothetical network developed to meet a directed date for the completion of an airborne radar development project. For purposes of illustration and comparison, assume that the project cost is $1,000,000 and the project time is 100 weeks. The technical risk assumed for this duration is classified as medium.

Most Efficient Plan

The network plan that results in the most efficient use of presently available resources in meeting the technical requirements of a project is the most efficient plan.[1] It does not consider cost or time limitations. Usually it results in the lowest technical risk for the contractor. On research and development projects it is usually more efficient to complete each phase before proceeding to the next. A notable exception is the paralleling of activities which are interdependent.

Figure 6B presents the most efficient version of the network developed in Figure 6A. Noninterdependent activities have been placed in series to gain efficiency and reduce technical risk. It is apparent that the time duration of the

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[1] Ibid.

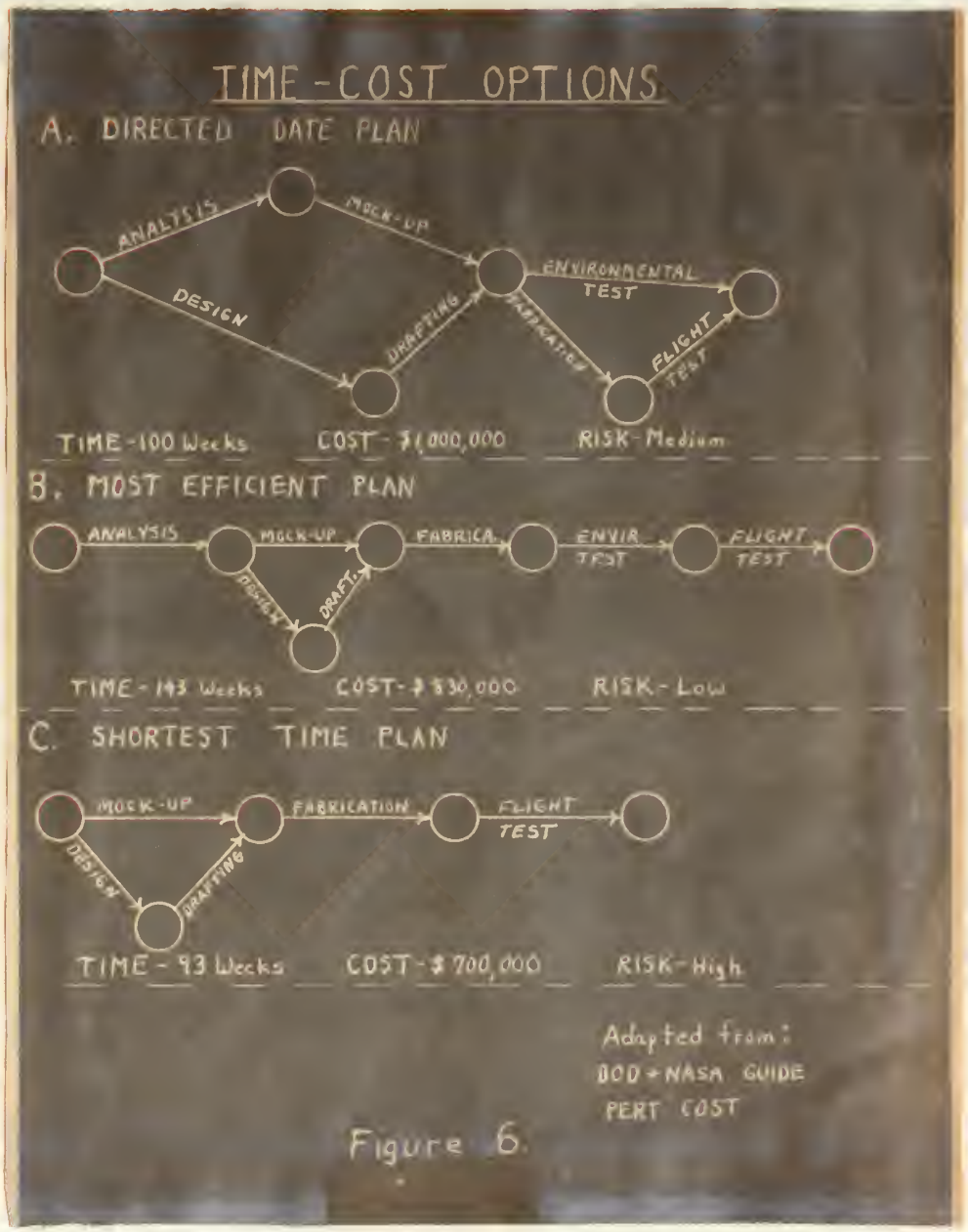
TIME-COST OPTIONS
A. DIRECTED DATE PLAN
ANALYSIS
MOCK-UP
DESIGN
DRAFTING
ENVIRONMENTAL TEST
FABRICATION
FLIGHT TEST
TIME-100 Weeks
COST-$1,000,000
RISK-Medium
B. MOST EFFICIENT PLAN
ANALYSIS
MOCK-UP
FABRICA.
ENVIR TEST
FLIGHT TEST
DESIGN
DRAFT.
TIME-193 Weeks
COST-$830,000
RISK-Low
C. SHORTEST TIME PLAN
MOCK-UP
FABRICATION
FLIGHT TEST
DESIGN
DRAFTING
TIME-93 Weeks
COST-$700,000
RISK-High
Adapted from:
DOD + NASA GUIDE
PERT COST

Figure 6.

program will increase. Conversely, since activities are performed in series, fewer resources can go farther, and the total project cost will decrease. Hypothetical project costs and duration, in comparison to the Directed Date Plan of Figure 6A, are $830,000 and 143 weeks.

Shortest Time Plan

Paramount in the objectives of the Shortest Time Plan is the fulfillment of the technical requirements of a project in the shortest possible time.[1] Its emphasis on time tends to increase technical risk. Technical risk increases due to the changing of technical approaches. The paralleling of activities reduces the safety inherent in activities performed in series. If similar but not identical projects have been completed previously, activities may be eliminated, and decisions are made on knowledge gained from the completed portions. Using nonspecific knowledge may be quicker but it entails greater risk. Figure 6C depicts the elimination of the preliminary analysis and the environmental test activities from the hypothetical radar development project.

Costs for the Shortest Time Plan may rise from the application of a higher level of effort to individual activities and increasing the numbers of activities carried out in parallel. Conversely, if activities are eliminated, the costs

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[1] Ibid.

may decline. In Figure 6C the costs have declined to $700,000 and the time has been reduced to 93 weeks. However, the degree of technical risk is now classified as high.

A Proposed Alternative Budget Option

The forementioned Time-Cost Option Supplement provides three possible time-cost-risk combinations out of a range of alternatives.[1] These do not represent all the combinations possible. Many plans may be developed to satisfy stated requirements in the three variables. Usry stated the possibilities when he wrote:

> The most efficient and shortest time plans are the practical ends of the spectrum and the alternative selected may fall on or between these end points.[2]

Does it not follow that options could be derived to reflect incremental changes in either of the quantifiable variables of time and cost?

Lewis's alternative budget proposal, discussed in Chapter I, suggested preparing a base budget and two alternatives for more and less than the base amount. In essence, this is done by the Time-Cost Option Supplement if one considers the Most Efficient Plan as the budget base. The budget reviewer would have specific evidence to illustrate the effects of a budget adjustment.

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[1] Ibid., p. 104.

[2] Milton F. Usry, "PERT--Cost and Expenditure Control," The Journal of Accountancy, March 1963, p. 86.

The alternatives proposed by the Time-Cost Option Supplement may reflect changes too large to be of practical use to the budget reviewer. It appears to be possible to develop alternatives which reflect smaller changes in program costs. If we develop plans for ±10% of the cost reflected in the base (Most Efficient) budget, we may have a much more pragmatic tool. These alternative plans will have a negligible cost if none of the cost and time estimates of the activities involved have to be changed. If changes are necessary, the cost of developing the alternative plans will be proportional to the number of activities requiring further planning and programming.

Examination of Figure 6 indicates that only one practical alternative can be developed if the Directed Date Plan is retained as the budget base. It reflects the maximum amount that can be effectively spent on the project. Hence, the development of an alternative of greater cost could only have interest to the reviewer beyond the DOD level. An alternative of lesser cost would still furnish the reviewer with facts for decisions. If only one alternative is developed, budget flexibility would be reduced.

Increased Flexibility

Regardless of which alternative is selected, the existence of other alternatives suggests that a greater degree of budget flexibility is available. Prior to ultimate approval of the budget and commencement of the program, there is no reason to

assume that the selection cannot be changed to any other available alternative. Subsequent to program commencement, it appears that the existence of various alternatives would allow a degree of flexibility. At a point in time, if a program was increased or cut back for military or nonmilitary reasons, the activities remaining for each alternative should enable the development of a more orderly program modification. In other words, management has a greater flow of information for decision-making.

CHAPTER V

SUMMARY AND CONCLUSIONS

Concepts Of Alternative Budgeting

The basic problem of governmental budgeting is: On what basis shall it be decided to allot X dollars to A and Y dollars to B when there are not enough dollars for both? The basis may be economic, political, or both. The important thing is that, regardless of the basis, economic concepts are applicable in determining the allocation of scarce resources among competing factors.

Lewis looked on the public budget as a problem of relative values to be examined by the methods of incremental analysis and relative effectiveness. These economic theories can be applied to enable more rational action by the budget preparer, reviewer, and approver. Use of the theory of relative effectiveness aids in the evaluation of different means of achieving a given objective. The theory of incremental analysis allows the additional values to be derived from each increment of expenditure. It facilitates the location of the point where the phenomenon of diminishing utility is encountered. The theories of relative effectiveness and

incremental analysis, properly applied, can assist in attaining the state where every expenditure is worth its cost in sacrificed alternatives. This is the essence of the theory of relative value. These three theories compose the economic concepts which are the basis for Lewis's system of alternative budgeting.

Features Of Alternative Budgeting

To facilitate the comparison of the relative merits of competing programs within a budget, Lewis presented a system which would allow the use of the economic theories of relative value, incremental analysis, and relative effectiveness. His alternative budget system required the preparation of a basic budget estimate and supplemental skeleton plans for alternative amounts for each program. The number of alternatives and increment size between alternatives would vary with the situation. Although problems still exist in the quantification of the input data for the economic theories, the lack of precise numbers does not invalidate the basic principles of the theories. While not perfect, the application of the theories and the development of the alternative plans does furnish the budget reviewer with a better tool to judge the effect of budget revisions.

Availability of the alternative plans allows various choices to be made along the hierarchical structure of the budget process. The plans furnish a degree of budget

formulation flexibility. Should modification of the approved budget be necessary, the plans supply information for the selection of changes. Flexibility appears to be inherent in alternative budgeting.

Status Of Alternative Budgeting In DOD

The program package concept establishes the framework which allows the application of the economic theories relative to alternative budgeting to the Department of Defense budget process. Planning determines the general needs for military capability. Inherent in planning is the need for balance among capabilities. It makes the planning problem more difficult, but only if balance is maintained will the marginal return of satisfaction be the same for all expenditures. It can be said that planning is the area that first considers the basic economic theory of alternative budgeting--the theory of relative value.

Within the programming phase of the DOD budget process, the cost and effectiveness of each proposed plan is compared with its competitors. The basic components of the programming system are the program elements and the programs. Program elements are integrated combinations of men, money, equipment, and installations whose effectiveness can be related to specific objectives. Program elements are grouped into nine basic programs for purposes of summarization, presentation and

comparison. In this manner the relative merits of the unlike program elements toward achieving a given mission can be compared. This is a practical application of the theory of relative effectiveness.

Costs are primarily considered from the viewpoint of effectiveness. However, the Department of Defense emphasizes the extra cost entailed by each alternative plan being compared. This emphasis on the value to be gained from each additional expenditure is applied incremental analysis.

This stress on incremental analysis is also evident in the Program Change Proposals used to propose modifications to the Five Year Force Structure and Financial Plan. Once the basic plan is established, all the emphasis switches to any changes proposed. In effect, incremental analysis is the basis for all subsequent program and budget decisions.

The use of the economic theories of relative effectiveness and incremental analysis in aiding in the solution of the problem of relative value in DOD is apparent. Defense budget preparation does have an economic basis. The economic concepts applicable to alternative budgeting have been applied within the Department of Defense.

At present, no alternative budgets, as conceived by Lewis, are prepared in DOD. During the planning and programming phases the comparison of alternatives, within a given proposal, seems more implicit than explicit. The emphasis is on

comparison of alternative programs not on comparison of intraprogram alternatives. It is fair to say that the complete alternative budget system does not explicitly exist in DOD. The underlying economic concepts are being utilized, but the physical system is not.

An Area For Complete Fulfillment

The Time-Cost Option Supplement to the DOD and NASA guide to PERT/COST presents alternative program plans to afford a selection which emphasizes the desired weight of time, cost, or risk. The examination of the interrelationships of the three considerations had been more implicit than explicit until the supplement was developed. Now, plans can be developed to emphasize the interrelationships. These plans are: the Directed Date Plan, the Most Efficient Plan, and the Shortest Time Plan. The project activity time and cost estimates are used to develop the basic directed date plan. Some additional estimates may be needed for the new or modified activities required by the alternative plans.

The plans provide three possible time-cost-risk combinations from a range of alternatives which are practically bounded by the Most Efficient and Shortest Time plans. Within these limits, any plan developed would actually reflect incremental budget options. If the Most Efficient plan were utilized as the base, the alternative plans would reflect

budget increases or decreases. If the Directed Date Plan were utilized as the base, they would only reflect a budget decrease. This reflects the pragmatic approach. When resources are limited, the usual budget choice results in allocations equal to or less than the budget request. Alternative budgeting is compatible with the plans that may be generated within the spectrum of the Time-Cost Option Supplement.

The complete integration of alternative budgeting with the supplement requires the development of plans which stress incremental changes in cost. These plans would also result in incremental changes in time and risk. Only supplemental plans which have a chance for adoption should be developed. The number of plans developed should reflect a compromise between budgetary need and increased administrative cost. Although the major administrative costs of developing the budget options would arise from those activities requiring change rather than realignment, each additional plan will result in additional cost. The point of diminishing return should not be passed. The development of the incremental cost option plans would fulfill the economic concepts and the physical requirements of the system of alternative budgeting.

Other areas may offer compatibility with alternative budgeting. This thesis suggests a specific area where the framework for adoption of alternative budgeting now exists. Although the present use of the Time-Cost Option Supplement is

not mandatory, the addition of budget alternatives appears to make it a more useful tool. Since PERT/COST programs represent a significant portion of the total Department of Defense research and development budget, it is recommended that the complete adoption of the alternative budget system be studied for these programs. If adopted, a significant move toward governmental budget flexibility may result.

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